THE TARNISHED PLANT-BUG (LYGUS PRATENSIS)(LINN.) (HEMIPTERA-MIRIDAE) IN ITS RELATION TO ALFALFA

by

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INTRODUCTION

The tarnished plant-bug has been appropriately called "the sparrow of the insect world." It has almost a world wide distribution, occurring in Europe, in practically all parts of the United States, and Canada. It has been reported from Alaska and Siberia. It has a very wide range of food plants, being a pest of nursery stock, ornamental plants, and many field and vegetable crops. It has a wide distribution in Kansas and, taking the whole season through, is the most numerous insect on alfalfa. It was first reported on alfalfa by Cockerell in 1894 but the present study is the first with special reference to alfalfa.

This paper contains a summary of the literature dealing with the tarnished plant-bug with the results of a study of this insect in its relation to alfalfa which was made by the writer during the past year.

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HISTORICAL

The tarnished plant-bug was first described by Linnaeus in 1746 in the first edition of a work on the fauna of Sweden. In this description he gave it the name of Cimex griseus and stated that it occurred in meadows. In the tenth edition of "Systema Naturae" he changed the specific name to pratensis which means "found in meadows." In America the tarnished plant-bug was first described by Thomas Say in 1831 in a work on North American Hemiptera, published at New Harmony, Indiana. He gave the species the name Capsus oblineatus. It seems, however, that this insect was collected in America as early as 1781, for it was described by Palisot de Beauvais in a book on insects collected in America and Africa between 1781 and 1797 published in parts between 1805 and 1821. Palisot de Beauvais gave it the name Coreus linearis. In 1847 Harris noted the identity of the species described by Say and Palisot de Beauvais and adopted the name given by the latter, but changed the genus name to Phytocoris. The tarnished plant-bug is referred to in early American economic literature, therefore, as Capsus

oblineatus and as Phytocoris linearis. Of late years, however, it has been known as Lygus pratensis and is so classified by Knight (1917) in a paper on the revision of the genus Lygus.

A series of specimens was sent to Dr. H. H. Knight for determination and it was found that two forms of Lygus occur on alfalfa at Manhattan, Kansas. These forms are Lygus pratensis oblineatus (Say) and Lygus pratensis strigulatus (Walk).

The name "tarnished plant-bug" is now used as the common name of this pest although it has been referred to at different times by other names, such as the "hop bug," the "chrysanthemum fly," and the "green meadow bug."

The tarnished plant-bug has often been described as a new species because it has such a wide distribution and range of food plants. Knight (1917) has compiled a synonymical list of the different names given to this species.

DISTRIBUTION AND HOST PLANTS

The tarnished plant-bug has a wide geographical distribution, having been found in nearly all parts of the world. It has been taken in the high altitudes of the Alps, even above the timber line, as well as near the seashore. It has been reported from Alaska and eastern Asia, as well as from the tropics, and in each country where it is found

it usually occurs in sufficiently large numbers to do serious injury to at least one of its many food plants.

The following list of its food plants with a short summary of the injury done was taken in part from Crosby and Leonard (1914):

Apple. Walsh (1860) in Illinois is the first to have recorded injury to apple blossom buds by the tarnished plant-bug. Riley (1870) records severe injury to apple trees in Missouri. Riley and Howard (1889) record a case in McPherson county, Kansas, where somewhat less than one-fourth of the apple bloom was destroyed. Theobald (1905) states that in that year this insect seriously injured the unopened buds of apples in England. R. I. Smith (1906) records an instance in Georgia in which apple grafts were seriously injured by tarnished plant-bugs. He states that while the leaves were badly curled and the growth was severely checked, nevertheless the trees were able to outgrow the injury almost entirely by the end of the season. Taylor (1908) describes and figures dimples in apples caused by the egg-laying punctures of the tarnished plant-bug. Lind (1911) describes in detail injury to apple nursery and orchard trees by this insect in Denmark.

Pear. Walsh (1860) is the first to have recorded the injury to the buds of pear. Wier (1872) records injury to

pear buds on both bearing trees and nursery stock. He alludes to this injury again in 1875 and describes an injury to the fruit which he attributes to the tarnished plant-bug, but which Crosby and Leonard (1914) state was probably caused by the false tarnished plant-bug (Lygus invitus). They seem to have based their deductions upon the description by Parrott and Hodgkiss (1913) of the injury done by the false tarnished plant-bug. Riley and Howard (1889) record an instance in McPherson county, Kansas, where one-quarter to one-third of the pear bloom was destroyed by the tarnished plant-bug. Theobald (1905) states that the insect is injurious to pear buds in England. Lind (1911) says that the insect causes considerable damage to pear leaf and blossom buds in Denmark.

Quince. Riley (1870) and Murtfeldt (1890) both refer to the tarnished plant-bug as being injurious to the buds and blossoms of quince but give no specific instances.

Peach. Lowe (1900) reports having observed the tarnished plant-bug puncturing peach fruits in June, causing them to wither and exude gum. Crosby and Leonard (1914) give a full discussion on injury done to peach nursery stock.

Plum. Wier (1872) reports serious injury to plums by this insect in Illinois. Theobald (1905) states that the insect has caused serious injury to plum buds in England.

Cherry. Raymond (1880) reports serious injury in Iowa to cherry blossoms.

Apricot. Murtfeldt (1890) states that the tarnished plant-bug does injury to blossoms and young shoots of apricots in Missouri.

Mulberry. Lind (1911) states that the tarnished plant-bug often damages mulberry trees in Denmark.

Bramble fruits. Forbes (1884) states that the blackberry and the raspberry are attacked by the tarnished plant-bug.

Currant. Cook (1876) states that in Michigan he saw currants severely injured.

Gooseberry. Murtfeldt (1890) records severe injury to gooseberries in Missouri.

Strawberry. Forbes (1884) first described buttoning in strawberries, which is caused by the tarnished plant-bug. He records a case in which a loss of $5,000 to $10,000 was sustained by a grower at Cobden, Illinois. Lind (1911) mentions it as being injurious to strawberries in Denmark.

Grape. Bruner (1895) states that the tarnished plant-bug is sometimes injurious to grapes. Murtfeldt (1902) records the injury to grape leaves in Missouri.

Potato. Curtis (1840) in England was the first to connect the tarnished plant-bug with tipburn of potatoes.

Beans. Davis (1897) states that considerable injury was done in Michigan during 1895 and 1896 to beans. The bugs punctured the pods causing growth to stop at that point.

Beet. Osborn and Gossard (1891) and Bruner (1891) state that the tarnished plant-bug is sometimes injurious to beets.

Celery. Troop (1892) mentions that the tarnished plant bug is injurious to celery. Davis (1893) states that it is one of the worst pests of this crop in Michigan.

Sea purslane. Rudow (1891) describes malformations of this plant caused by the tarnished plant bug.

Cabbage. Riley (1870) states that the tarnished plant-bug is sometimes injurious to cabbage.

Cauliflower. Lind (1911) states that in Germany the tarnished plant-bug is injurious to cauliflower.

Turnips. Tullgren (1911) in Sweden, and Lind (1911) in Denmark state that turnips are sometimes attacked by this insect.

Salsify. Webster (1890) states that nymphs and adults of the tarnished plant-bug were found feeding in abundance on salsify in Ohio.

Cucumbers. Riley (1870) records a case of severe injury to late planted cucumbers at Chicago, Illinois.

Tobacco. Lintner (1890) states that the tarnished plant-bug was found feeding on the tobacco plant.

Cotton. Vassilier (1914) mentioned Lygus pratensis as occurring on cotton in Turkestan. Morrill (1917) reports it was a cotton pest in the southwestern United States.

Hydrangea. Lind (1911) states that hydrangeas are sometimes injured by the tarnished plant-bug in Denmark.

Chrysanthemum. Webster (1888) reports that the tarnished plant-bug attacks the unopened buds of chrysanthemums, causing an injury now known as blind growth or blind buds.

Dahlia. The tarnished plant-bug is a very serious enemy of the dahlia. It punctures the lips and unopened buds causing them to stool out. Eggs are often deposited in the buds and tender tips. Harris (1841) was the first to call attention to this injury to dahlias. Lind (1911) discusses at length injury to dahlias by the tarnished plant-bug in Denmark.

Peony. Pugsley (1880) reports a case in 1877 in Kansas where over one thousand peony buds were destroyed by the tarnished plant-bug.

Carnation. Davis (1896) refers in a brief statement to injury to this plant.

Aster. Harris (1843) was the first to note the injury to asters.

Other compositae. Arnold (1912) states that he has noted injury by the tarnished plant-bug to: Brachycome, Calendula, Centaurea moschata, Tagetes, especially Tagetes erecta, and the everlastings, particularly Acroclinium and Helichrysum. Harris in 1841 had already called attention to the injury to marigold.

Antirrhinum and salvia. Arnold (1912) mentions injury to these plants.

Elm. The tarnished plant-bug was taken by the writer on elm at Manhattan, Kansas, in 1927.

Balsam. Harris (1841) was the first to report injury to balsam.

Urtica. Kaltenbach (1874) mentions this insect as injurious to Urtica dioica.

Pastinaca. Kaltenbach (1874) lists the tarnished plant-bug as an enemy to Pastinaca sativa.

Fuchsia. Forsch (1889) mentions this plant as being injured by the tarnished plant-bug.

Dicentra. Pugsley (1933) states that in Kansas in 1927 the tarnished plant-bug seriously injured this plant.

Poppy. Theobald (1905) records a case in England in which beds of poppies were ruined by the tarnished plant-bug in July and August.

Sweet pea. Weed (1901) described a case of severe injury to sweet peas in New Hampshire. The bugs punctured the flower stalk, usually just below the bud, causing it to wither and die.

Lilac. Pugsley (1930) mentioned injury to lilacs by the tarnished plant-bug.

Dwarf mountain June berry. Pugsley (1930) records the destruction of the blossom buds of this shrub by the tarnished plant-bug.

Corn. Cook (1878) states that in Cass county, Michigan, corn was injured by this insect to a considerable extent.

Wheat. Cook (1878) states that 10 per cent of the wheat crop was destroyed. Schoyen (1911) records the tarnished plant-bug as injurious to wheat in Norway.

Barley and Oats. Schoyen (1911) records the insect feeding on these grains.

Timothy. Schoyen (1911) records the insect feeding on timothy grass.

Alfalfa. Cockerell (1894) records the insect as abundant on alfalfa. Quaintance (1901) mentions it as occurring on alfalfa. The writer finds it the most numerous pest on alfalfa at Manhattan, Kansas, taking the whole season through. In the spring there is a gradual increase in infestation on alfalfa which tends to show that it is preferred as a food plant and for oviposition.

Vetch. Kolotarevsky (1915) reports the tarnished plant-bug on vetch. It has been found that they breed quite freely on this plant at Manhattan, Kansas.

Sweet clover. The tarnished plant-bug was taken by the writer on this plant at Manhattan, Kansas, in 1927.

LIFE HISTORY AND HABITS

Hibernation

It has been found that the adults pass the winter in bunch grass, under trash, and around old buildings, as well as in clumps of alfalfa stubble and Sudan grass. On December 23, 1927, three clumps of alfalfa were examined for overwintering forms. Two adults were found in one clump, one in another clump, and none was found in the third clump. Of these three, two were females and one was a male. On November 24, 1927, three adults were found among forest leaves in a hole in the side of a creek bank where they had evidently gone into hibernation. A single female was taken in bunch grass March 7, 1927. Forbes (1884) states that the older nymphs also survive the winter under the leaves of mullein plants. Wier (1875) and others state that only the females overwinter, the males dying in the fall after copulation. Crosby and Leonard (1914) state that they have

found males and females about equally abundant in hibernation. They infer that copulation takes place in the spring by saying, "We are told by S. G. Bishop, who has studied the female reproductive organs in the fall, that no developed eggs were found in females collected at Ithaca, New York, in October." It was found, however, in the work done at Manhattan that females taken from hibernation on March 7, 1927, and on December 23, 1927, deposited eggs quite readily on alfalfa in the greenhouse within a few days. The eggs proved to be fertile.

Overwintering studies so far indicate that just the adults overwinter, the nymphs either become adult or die by the first cold nights in the fall. On November 5, 1927, while collecting tarnished plant-bugs for overwintering studies the writer found one full grown nymph while six hundred adults were taken, showing that the percentage of nymphs at this time is very low. Hamman (1910) states that among tarnished plant-bug adults taken from mullein plants February 15 and 17 about fifty per cent were dead in most cases. On November 5, 1927, two hundred adults were put into a screen cage over clumps of alfalfa and on January 6, 1928, eighty-nine were recovered. Of these, thirty-one were dead showing a mortality of 33.7 per cent of those recovered. In clumps examined in the alfalfa fields a mortality

of about 30 per cent was found for January 1, 1928. This mortality rate is very high for the time of year and it is thought by the writer that this is due to the activity of the overwintering forms on any warm day in winter as adults have been taken by sweepings or out of hibernation some time in every month of the year except January.

Eggs and Oviposition

The egg is about 1 mm. in length and about 0.30 mm. in width. It is oval at the posterior end and tapers gradually toward the anterior end. The anterior end is slightly curved and constricted near the end. It is about the color of milky water, appears smooth but under the lens shows delicate ballooted sculpturing. In Plate I the egg is shown in cross section and in longitudinal section in the tissue of an alfalfa stem. The cross section shows the valves of the ovipositor which is also in cross section.

When the egg is almost ready to hatch the eyes of the embryo appear pink through the egg shell. The dorsal abdominal stink-gland may also be distinguished through the egg shell at this time.

Eggs are deposited in the stems and leaves of many different plants. A female taken from hibernation in lunch grass March 7, 1927, and placed on an alfalfa plant in a

chimney cage in the greenhouse deposited two eggs by March 10, 1927.

On July 15, 1927, the writer observed a female in the act of oviposition on alfalfa in the field. By lying down on the ground and crawling slowly through the alfalfa it was possible to get very close to the adults. At one time four adults were within two feet of the writer's face. They apparently did not notice that anyone was near. One adult was wandering slowly about with the beak in readiness for insertion. It stopped very often and appeared to test the stem with its beak. It would occasionally hop or fly from one plant to another or from one plant stem to another. Once it alighted on a crab-grass plant and kept on testing with its beak as if the kind of plant made no difference. It eventually came to a clump of blossom buds and inserted the beak but soon withdrew it. It immediately extended the ovipositor forward and inserted it among the flower buds. It then remained quiet for about thirty seconds, then withdrew the ovipositor. The egg was found later among the blossoms with the aid of the binoculars.

Oviposition was also observed with females on potted plants in the insectary and on two occasions females were found dead or nearly dead on an alfalfa plant with the ovipositor inserted, and though sections were made of the ovi-

positor and the stem no reason was found for the female dying with ovipositor inserted. It is possible that in confinement the female attempted to oviposit on the tougher parts of the stem and the recurved hooks near the end of the ovipositor caught in the tissue. Eggs are deposited on alfalfa in any part of the plant above ground but the leaf buds and the ends of freshly cut off stems are preferred for oviposition. In cage experiments it was possible to get as many as fifteen eggs inserted in the end of a single stub. When eggs are inserted in the leaf buds the leaves are sometimes punctured and after the leaves emerge from the bud the holes are very conspicuous. This type of injury is very readily found in the field and may serve as a source of entrance for disease organisms. The highest number of eggs secured from one female was thirty-nine but it is thought that in nature the number is much higher than this because it is not possible to keep the females alive in captivity for a very long time, usually from five to ten days at the most, during warm weather. The egg stage was found to be from eight to twelve days depending on weather conditions.

The Nymph

The tarnished plant-bug passes through five nymphal

instars in its development from the egg to the adult. Wings appear with the fifth molt. Plate II shows the stages from the egg to the adult inclusive and Table I shows measurements of the different nymphal instars and the average length in days of each instar. (Table I included herein as page 17).

In the first two instars the nymph (Plate II) is yellowish green in color and is often mistaken for a green aphid. It may be distinguished from the aphid by the presence of a dorsal abdominal stink-gland, which is blackish in color, and also by the absence of cornicles. Even the young nymphs are very active and run rapidly about over the host plants.

The third, fourth, and fifth instars are comparatively easy to distinguish from each other as well as from the earlier stages. In the third instar a pair of dark spots is distinguishable on each of the first two thoracic segments and becomes more conspicuous in the fourth and fifth instars. Distinct wing pads are present in the fourth and fifth instars and the nymphs begin to take on some of the distinctive markings of the adult. The nymphs first appear on alfalfa at Manhattan, Kansas, the last week in April or the first of May. The earliest date nymphs were taken was April 28.

TABLE I. MEASUREMENTS OF NYMPHAL INSTARS

Instar	First	Second	Third	Fourth	Fifth
Greatest width across head	0.35 mm.	0.50 mm.	0.70 mm.	0.95 mm.	1.00 mm.
Narrowest width across head	0.30 mm.	0.45 mm.	0.60 mm.	0.80 mm.	0.90 mm.
Average width across head	0.30 mm.	0.47 mm.	0.64 mm.	0.82 mm.	0.97 mm.
Greatest length	1.40 mm.	1.65 mm.	2.95 mm.	3.90 mm.	4.40 mm.
Shortest length	0.90 mm.	1.30 mm.	1.15 mm.	2.15 mm.	2.75 mm.
Average length	1.15 mm.	1.54 mm.	1.98 mm.	2.73 mm.	3.53 mm.
Average length of instars in days	5	3.6	4	5.5	6.2
Individuals measured	5	5	5	5	5

The Adult

The adult tarnished plant-bug (Plate II) is about 6 mm. in length and 1.1 mm. across the head including the eyes. The adults are quite variable in coloration, ranging from light yellowish brown with dusky blotches to very dark brown with very dark blotches. In most cases the females are lighter in color than the males, especially on the under side.

Generations

There appears to be no recorded instance where the number of generations has been worked out definitely. This is probably because this insect is difficult to rear in captivity. It was found by the writer that there are four generations on alfalfa at Manhattan, Kansas. This was determined by cage rearings and by collecting in the field. Rearing in captivity was found difficult but by replacing the insects in the cages with others of the same instar from the field, it is thought that very accurate results were obtained. Starting with the overwintering adults as the first stage of the first generation it was found that the adults of succeeding generations appeared about the following dates: May 21; July 6; August 15; and Septem-

ber 20. The adults of September 20 went into hibernation, and a large portion survive the winter and deposit eggs the following year.

INJURY

The injury caused by the tarnished plant-bug is usually not so apparent on alfalfa as on some other plants because feeding is distributed to all parts of the plant above ground and because alfalfa, during a good growing season, grows so rapidly that the injury is overcome. Several tests were made with potted plants to determine the injury done. Ten tarnished plant-bugs were placed on each of several plants enclosed in chimney cages and other plants were enclosed in chimney cages as checks. It was found that at the end of from seven to ten days the plants containing the tarnished plant-bugs were entirely killed while the checks were growing vigorously. (Plate III) It was noticed that the infested plants had a tendency to stool while the non-infested plants did not. In the field twenty-five tarnished plant-bugs were put on an alfalfa clump within a screen cage and another clump used as a check, and although the infested plant was not killed it was very much dwarfed and as in the case of the potted plants had a tendency to stool.

The question arose as to whether the injury was caused by feeding or oviposition so another series of potted plants was used and on a part of the plants only females were placed and on another part of the plants males were placed. It was found that the plants containing only males were killed as quickly as the plants containing only females. It was found that eggs were deposited in the plants where females were confined.

Where several eggs are inserted near the same place in an alfalfa stem the stem and leaves above wilt and eventually die. An occasional plant can be found in the field with this type of injury apparent but eggs have never been found inserted in the stems of such plants. It is possible that in all cases examined that the eggs had already hatched. Plate I shows sections of plant stems with eggs inserted. These sections show no injury except mechanical injury caused by the oviposition process.

When an egg is inserted through a leaf bud it quite frequently happens that all three leaves are punctured and when the leaves emerge from the bud, holes may be seen. These holes get much larger than the egg and may serve as an entrance for disease organisms. This type of injury has been found in the field and an egg shell was found in one instance.

The tarnished plant-bug has been mentioned as a possible carrier of many plant diseases and in some cases has been shown to be the carrier of the causal organism. Stewart (1916) proved experimentally that the tarnished plant-bug is capable of transmitting the fire blight organism (Bacillus amylovorous (Burr.) Trev. from one host plant to another. Caesar (1918) states that spinach blight is carried by the tarnished plant-bug. MacLennan (1922) states that the tarnished plant bug is the cause of heart-rot in celery. The tarnished plant bug is well fitted to be a carrier of plant diseases. Its piercing mouth parts make it possible for this insect to transmit infective material directly from one plant to another by mechanical means. It is a vigorous flier which would enable it to carry disease organisms long distances even against the wind or from low places to higher places in the opposite direction from natural dissemination by drainage water. It has a large variety of food plants and would, therefore, make an important disease carrier where an organism has two or more host plants. Since it overwinters as an adult there is the possibility of an organism surviving the winter in its alimentary tract or otherwise associated with the insect. With these qualifications in view it was decided to study the tarnished plant-bug as a possible carrier of the bacterial

wilt and root rot organism (Phymatotrichum omnivorum T. & G.)

This disease appears to be one of the worst pests attacking alfalfa, either insect or plant disease. In experimenting with this disease several difficulties are involved. First, the incubation period is from six weeks to three months, making it impossible to grow many series of plants and make inoculations under entirely sterile conditions in the short time that this work was under way. Second, it has been noticed that the disease develops best on plants two or three years old so that it was possible that the plants grown during the current year might not be susceptible. Third, unless the disease is in an advanced stage macroscopical symptoms are not easily detected and, therefore, complicated methods of staining and isolation must be used to determine whether or not the organism is present.

In the first test plants were grown from seed in earth that had been heated with live steam for three hours. The weather was very damp during the season and many of the plants died from the effects of the moist weather. Some, however, were inoculated. The method used in inoculation was to put tarnished plant-bugs on an alfalfa plant known to be infected with the disease and from twelve to twenty-four hours later to transfer the insects to the healthy

plants. Just a few plants of the first planting lived long enough to be inoculated. In about ten weeks these plants were examined and isolation of the organism attempted. The results proved negative. On the advice of Dr. J. L. Weimer of the Department of Botany, two year old plants were used in the second tests. These plants were secured from the Botany experimental plats. Inoculations were made on November 8, 1927, in the greenhouse in the same way as with the first set of plants. The plants were examined January 11, 1928, and it was found that all the plants except one, including the checks, had the disease. It was discovered that in the plat from which the plants came fifty per cent of the plants had the disease. No symptoms of the disease were noticed at the time the plants were secured from the plat but since there was such a high percentage of infected plants in the field plat this set of results was not considered as either a positive or a negative case of transmission of the disease by the tarnished plant-bug. A third set of plants was used from a field which was seeded to alfalfa in the spring of 1927. Inoculations by the tarnished plant-bug were attempted as before. These inoculations were made October 25, 1927, and examinations were made January 11, 1928. Three of the inoculated plants showed slight symptoms and two of the checks showed slight symptoms. Isolations

were attempted from parts of the roots and sections were made and the staining test was made. In all cases the results were negative.

These tests show that the transmission of the bacterial wilt and root rot disease by the tarnished plant-bug is at least not readily accomplished under the conditions of these experiments. In future experiments with the transmission of this disease it would be advisable to use only plants grown under sterile conditions because macroscopical symptoms of the disease cannot be detected until from six weeks to three months after infection takes place and, therefore, plants from the field might have the disease though not showing any apparent symptoms. It is the opinion of the writer that the time between feeding of the insect on the diseased plant and feeding on the healthy plant is important as it appears that the organism does not develop readily in competition with other organisms.

CONTROL

Satisfactory control of the tarnished plant-bug is still an unsolved problem. There are few species of really destructive insects which seem so free from natural checks upon their increase as this insect. Birds do not prey upon it, because of its offensive odor. Forbes (1883) states,

"In the food of three hundred and fifteen robins, cat-birds and other thrushes taken at all seasons of the year and carefully studied only two birds, both robins, had eaten this species and these in trivial amounts." One hundred and eight blue-birds had not eaten it at all. Crosby and Leonard (1914) mention a minute mymarid parasite, Anagrus ramosus Crosb. and Leonard, as destroying the eggs of the tarnished plant-bug to a slight extent. The writer has observed two species of spiders, a small black ant, and a tree cricket feeding at different times on the nymphs of the tarnished plant-bug in sweepings from the field. The writer has also observed chrysopids feeding on the nymphs in the field. It is the opinion of the writer, however, that this insect, even in the nymphal stages, is too active to be easy prey for ordinary insect predators.

The use of contact insecticides against the tarnished plant-bug have been found to be ineffective in most cases and since this pest has sucking mouth parts the stomach poisons would be out of the question. Haseman (1918) states that, "Present day insecticides have no place in a campaign against this pest. McGregor (1915) in working with Lygus elisus Van Duzee, obtained good control by dusting with resublimed sulfur. He states that elisus was killed in cage experiments in thirty minutes when resublimed sulfur was

dusted near the cage even though none of the dust actually came in contact with the insect.

In view of McGregor's results the writer on October 20, 1927, dusted three plots of alfalfa using resublimed sulfur on one plot, sodium fluosilicate on another, and calcium cyanide dust on a third plot. The dust in each case was applied at the rate of 20 pounds per acre. It was applied with a knapsack duster in the early morning when the insects were less active than at midday. The results were unsatisfactory, practically no bugs being killed except a few on the cyanide dust plot. The temperature was 70° F during this experiment while McGregor's work with oligus was done at a temperature of 100° F. which might explain the difference in results obtained. To test resublimed sulfur further three tarnished plant-bugs were placed in a vial and dusted thoroughly with resublimed sulfur. The vial was stoppered with cotton. Two days later the stopper was removed from the vial and the tarnished plant-bugs crawled to the mouth of the vial and flew away.

Very satisfactory control was obtained in regulating the time of cutting alfalfa. About seven days after the bulk of the second generation nymphs had become adult the alfalfa was cut. It was thought by the writer that the bulk of the eggs for the next generation had been laid and would

be destroyed or carried away with the harvest. Surveys were made to see if the next crop would be very badly infested and it was found that the infestation was very low. This method of control deserves further investigation. The writer believes, however, that this method of control would not be practicable for the control of all broods of the tarnished plant-bug as the life cycle of the tarnished plant-bug takes about ten days longer than the time between cuttings of alfalfa.

Winter burning was thought of as a possible means of control and though the fields were located where the adults were in hibernation in the alfalfa clumps in large numbers there was not enough dry vegetation to make the burning process successful.

SUMMARY

It was found that the tarnished plat-bug overwinters as an adult in bunch grass, Sudan grass clumps, in old rubbish and weeds in waste places, among forest leaves, and in practically any place that will afford protection. Alfalfa has been found important in providing overwintering quarters. Both males and females overwinter. Winter mortality was found to be thirty per cent on January 1, 1933.

Eggs are inserted in the stems and leaves of alfalfa.

The leaf buds and the ends of freshly cut off stems seem to be the most attractive places for oviposition. The egg stage may be from eight to twelve days depending on weather conditions.

There are five nymphal instars between the egg and adult stages.

There are four full generations a year on alfalfa in Kansas.

An infestation of ten tarnished plant-bugs caused the death of potted alfalfa plants in from seven to ten days while the check plants grew vigorously. An infestation of twenty-five tarnished plant-bugs on a clump of alfalfa in the field caused stooling of the plants and also a dwarfed condition. Where several eggs are inserted near one place in the stem of an alfalfa plant the leaves and stem above that place will eventually die.

Experiments conducted to try to determine whether the tarnished plant-bug may carry the organism causing alfalfa wilt and root rot showed that the disease is not easily transmitted in this way, at least under the conditions under which the experiments were conducted.

Very good results were obtained in trying to control the tarnished plant-bug on alfalfa by cutting the alfalfa about seven days after the bulk of the insects had become

adults. It was thought that the bulk of the eggs had been deposited and were either destroyed or carried away with the harvest.

The use of sodium fluoride, calcium cyanide dust, or resublimed sulfur as a contact insecticide against the tarnished plant-bug proved unsatisfactory.

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Plate I. Camera lucida drawings of tarnished plant-bug eggs in alfalfa stem.

Fig. 1. Cross section of egg in position between valves of ovipositor.

(a) Partly developed embryo in cross section.

(b) Egg shell.

(c) Cross section of valve of ovipositor.

(d) Plant cells crushed by the process of oviposition.

(e) Normal plant cell.

Fig. 2. Longitudinal section of egg showing position in stem and injury to plant tissue.

(a) Partly developed embryo in longitudinal section.

(b) Egg shell.

(d) Plant cells crushed by the process of oviposition.

(e) Normal plant cell.

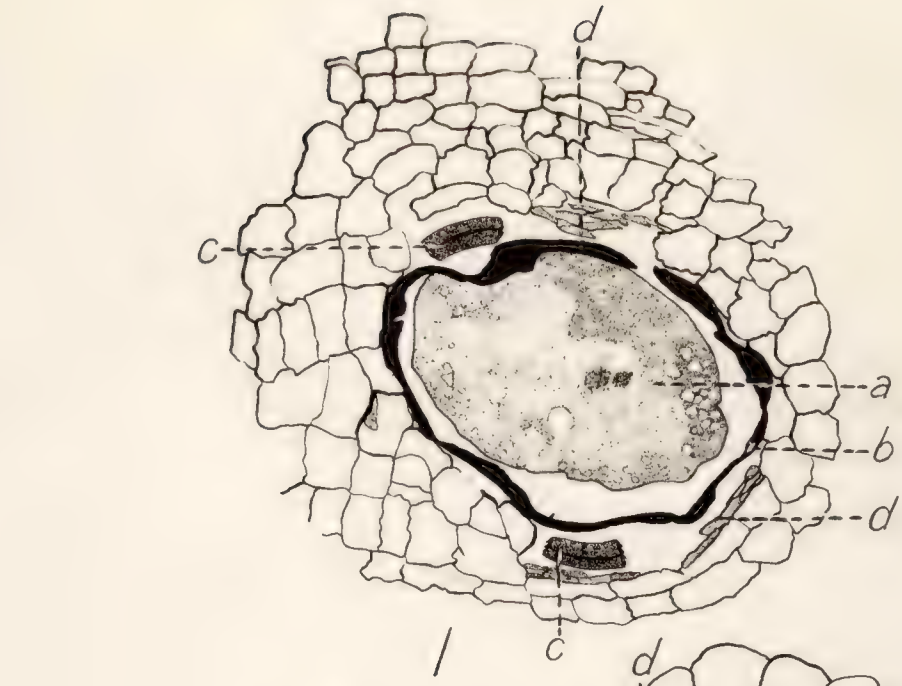

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Plate II. Drawings of eggs, nymphs, and adult of the tarnished plant-bug.

Fig. 1. First instar nymph (X 10)

Fig. 2. Second instar nymph (X 10)

Fig. 3. Third instar nymph (X 10)

Fig. 4. Fourth instar nymph (X 10)

Fig. 5. Fifth instar nymph (X 10)

Fig. 6. Adult (X 10)

Fig. 7. Eggs of tarnished plant-bug inserted in alfalfa stem and leaves. (Drawing of eggs by E. Fred Prince.)

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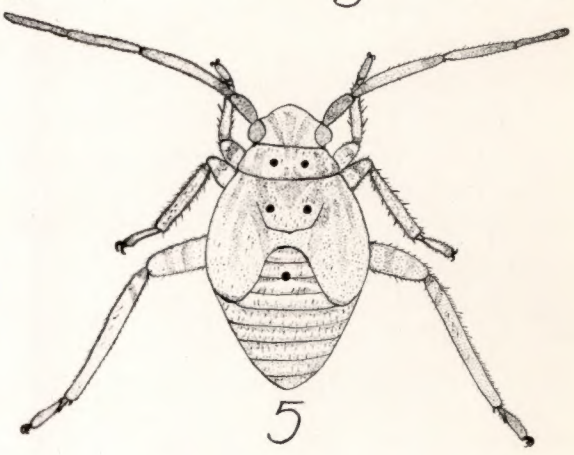

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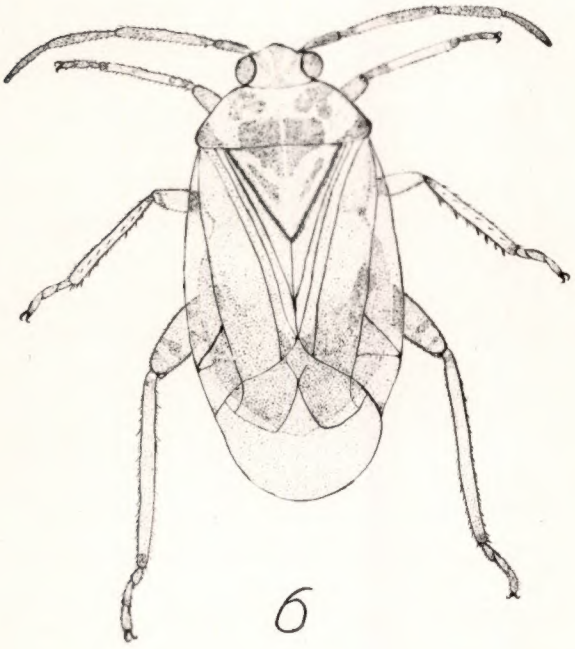

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Plate III.

Fig. 1. Photograph of female in the act of oviposition. Notice ovipositor near middle of abdomen and inserted in alfalfa stem.

Fig. 2. Photograph showing dead alfalfa plant caused by an infestation of 10 tarnished plant-bugs.

Fig. 3. Photograph of check plant on which there were no tarnished plant-bugs. Note vigorous growth.

PLATE III

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Date Due